CENTER for BIOLOGICAL DIVERSITY Because life is good.

July 8, 2014

California Coastal Commission
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Re: Scientific evidence on the harms that fracking chemicals pose to California's coastal marine life

Dear Commissioners:

We are writing on behalf of the Center for Biological Diversity to relay important scientific information documenting the dangers that fracking chemicals pose to California's coastal marine life. The Center analyzed the chemicals used during 19 fracking events in California state waters reported during 2011 to 2013. Scientific studies indicate that at least 10 of the fracking chemicals routinely used during these fracking events could kill or harm a broad variety of marine species, including sea otters, fish, and benthic invertebrates.

Here we present evidence that (1) fracking chemicals are entering California's coastal waters, (2) fracking chemicals routinely used off California's coast can kill or harm coastal marine life, and (3) the toxicity of fracking chemicals can increase when they are combined with other chemicals and environmental stressors. We also present new studies that indicate that produced water from offshore oil and gas drilling may be more harmful than previously assessed by the Coastal Commission.

This evidence further demonstrates that fracking is an inherently dangerous practice that has no place in California's fragile coastal ecosystem. Fracking increases the environmental damages and risks beyond those of conventional oil development and poses a threat of serious harm to marine life and the coastal environment.

I. Fracking Chemicals Are Entering California's Coastal Waters Through the Discharge of Wastewater from Oil Platforms in Federal Waters and Through Leaks and Spills in State and Federal Waters

Oil companies have fracked more than 200 offshore wells off southern California, including Huntington Beach, Long Beach, and Seal Beach, as well as in federal waters in the Santa Barbara Channel during the past two decades (AP 2013). In federal waters off California's coast, oil companies are discharging fracking fluid into the ocean as part of wastewater discharge, or reinjecting the fluid underground. The Coastal Commission acknowledges that approximately half of the platforms in the Santa Barbara Channel discharge all or a portion of their wastewater directly to the ocean.[1] On 24 January 2014, the EPA approved a General Permit that allows oil companies to discharge more than 9 billion gallons of wastewater, including fracking chemicals, into the ocean off California's coast annually (USEPA 2014a). The permit places no limits on fracking chemicals that may be discharged with produced waters.

In state waters, fracking fluids are reinjected underground in the originating reservoir or transported for onshore underground injection. Yet, even this disposal method can result in leaks. For example, 30% of offshore oil wells in the Gulf of Mexico experienced well casing damage in the first five years after drilling, and damage increased over time to 50% after 20 years (Vengosh et al. 2014 see also Davies et al. 2014). Loss of well casing integrity is a one of the main pathways for contamination of ground and surface waters (Davies et al. 2014).

Fracking chemicals can also enter state and federal waters through a number of other pathways, including leaks and spills of fracking fluids, flowback, and produced water at wells, platforms, and pipelines, and during transportation of chemicals to or from the well. Spill records from platforms off California indicate that accidental spills of oil and other hazardous substances into the marine environment routinely occur during normal operations. Bureau of Safety and Environmental Enforcement (BSEE) records show that four large spills over 50 barrels and five spills between 10 and 49 barrels occurred from OCS platforms in federal waters off California between 1990 and 2013. The largest of these was the 1997 spill from platform Irene that released 163 barrels of crude oil into California's coastal waters. A 2001 Minerals Management Service projection calculated the risks of a 1,000 barrel or greater spill from offshore California operations as 41.2% (Federal waters) and 8.4% (State waters) over the upcoming 28 years (McCrary et al. 2003). The likelihood of a 50-999 barrel spill was estimated at 95% (Federal waters) and 39% (State waters) for the same period.

Smaller spills occur on a frequent basis off California. Reports from the California Office of Emergency Services (OES) document more than 600 spills of oil, produced water, drilling muds, and other hazardous substances between 1993 and April 2014.[2] With the exception of 2006, every year since 2001 has seen at least 30 spills. As recently as March 5, 2014, an estimated 1,000 gallons of a 15% hydrochloric acid solution were spilled from platform Hondo. A 2004 entry shows that 600 gallons of an unknown oil containing polychlorinated biphenyls (PCBs), which are persistent organic pollutants and endocrine disruptors, leaked from the drainage system of an unidentified platform over a 10-year period. Spills resulted from numerous sources including pipeline, hose or tube leaks, overflowed tanks, failed valves, worker accidents, and vessel collisions.

Although the OES-reported spills were often small in volume, independent researchers have found that platform operators have consistently underreported spill volumes.

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[1] *See* Coastal Commission Consistency Determination, General NPDES permit from discharges of offshore oil and gas platforms, http://documents.coastal.ca.gov/reports/2013/6/W13a-6-2013.pdf.

[2] Spills were determined by filtering the OES reports to only include spills reported from platforms, then checking entries individually to ensure they were related to an offshore oil platform. Entries regarding orphan sheens, unknown sheens, unrelated vessel discharges, or attributed to natural seeps were evaluated individually and removed if there was no reported mechanism of release from the platform.

Oceanographers from Florida State University and Skytruth used high resolution satellite images to analyze the size of oil slicks in the Gulf of Mexico relative to the reported spill volumes.[3] The project estimated that oil spill volumes were typically 13 times greater than what was reported (Schrope 2013). The researchers attributed the consistent underreporting to a regulatory structure that relies on self-reporting and punishes failures to report incidents but not incorrect volume estimates. The same regulations apply to California offshore operations, creating incentives to underreport spill volumes.

The aging of offshore infrastructure poses an added risk for spills and leaks in state and federal waters, which will be exacerbated as fracking operations extend the productive lifetime of wells, platforms, and pipelines. Aging poses risks for corrosion, erosion, and fatigue stress to subsea pipelines, subsea equipment, load-bearing structures, and drilling and wells (PSA Norway 2006). Subsea pipeline corrosion appears to accelerate over time (Mohd and Paik 2013), and can act synergistically with fatigue stress to increase the rate of crack propagation (PSA Norway 2006). In the Gulf of Mexico, Iledare et al. (1997) calculated that a 1% increase in platform age corresponded to a 0.4% absolute increase in accident rate.[4] A recent analysis covering 1996-2010 found that accident incident rates, including spills, increased significantly with platform age (Muehlenbachs et al. 2013).

Finally, fracking-related leaks and spills are prevalent at onshore facilities, providing further evidence that leaks and spills are an inherent risk of fracking operations. For example, Brantley et al. (2014) compiled data on fracking-related spills from unconventional shale wells in Pennsylvania between May 2005 and June 2013. The analysis found 32 spills of over 400 gallons with impacts to water bodies: 9 spills of brine (e.g. flowback and/or produced waters), 9 spills of drilling muds/fluids, 7 spills of gel or fracking fluids, 5 spills of hydrostatic test waters or sediments, 1 spill of diesel fuel, and 2 spills that were unknown in nature. Spills occurred due to trucking accidents, well blowouts, and leaking tanks, valves and pipes. Spill volumes ranged as high as 227,000 gallons, and spill incidents continued to increase from 2008 to 2013 even though new wells per year decreased.

These studies demonstrate that fracking increases the hazards of conventional offshore production by introducing new toxic chemicals that are hazardous to marine life, and increasing the risks that toxic chemicals will enter the marine environment.

II. Scientific Studies Demonstrate that Fracking Chemicals Used Offshore in California Can Harm or Kill a Broad Array of Marine Species

The Center analyzed the chemicals used during 19 fracking events at 19 different wells in California state waters reported during 2011 to 2013 on FracFocus.[5] All 19 fracking events occurred in Long Beach Harbor within two miles from shore. We found scientific studies

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[3] Methodology available at http://oil.skytruth.org/oil-spill-reporting-resources/how-we-determine-oil-spill-volume

[4] An absolute increase such that if a 10 year-old platform had an 8% accident rate, an 11 year-old platform would be expected to have an 8.4% accident rate.

[5] The oil and gas industry has successfully resisted the full disclosure of fracking chemicals. However, since January 1, 2014, interim regulations under SB4 requires operators to disclose the chemicals used in their operations in a publicly available chemical report within 60 days of completion.

indicating that at least 10 fracking fluid chemicals used offshore in California could kill or harm a broad variety of marine organisms, including sea otters, fish, and invertebrates, if released into the environment. Six of these 10 chemicals were used in all 19 frack jobs.

The Table below summarizes the scientific studies documenting the harmful effects of these 10 fracking chemicals on marine species, followed by scientific summaries of four of the most toxic chemicals: nonylphenol ethoxylates, methylisothiazolione, phenol formaldehyde resins, and boron compounds. Nonylphenol ethoxylates are particularly toxic to marine species, are persistent in the marine environment, and have been found to bioaccumulate across trophic levels. We could not assess the full extent of the risks of the fracking chemicals used off California because oil companies kept the identity of some chemicals hidden under the claim of trade secret protections. In all 19 fracking events, trade secret protections were used to hide the specific identities of surfactants and phenolic compounds which can be toxic to marine life.

Previous research has reported that 40% of the chemicals added to fracking fluids have been found to have ecological effects, indicating that they can harm aquatic and other wildlife (Colborn et al. 2012). While more scientific study is urgently needed, this analysis demonstrates that fracking chemicals that can harm or kill marine life are routinely being used in fracking events off California's coast. Given the potential for harm, we are particularly concerned that the EPA imposes no limits on the discharge of fracking chemicals to federal waters off California.

Ten Harmful Fracking Chemicals Used in 19 California Offshore Wells			
Chemical (CAS identifier)	Number of Wells Used	Known Toxic Effects on Marine Life	Sources
Nonylphenol Ethoxylates (9016-45-9)	16	Nonylphenol is persistent in the aquatic environment, moderately bioaccumulative, and extremely toxic to aquatic organisms as an endocrine disruptor and inhibitor of development, behavior, growth, and survival	USEPA 2010; Cailleaud et al. 2011; Diehl et al. 2012
Methylisothiazolinone (26172-55-4, 2682-20-4)	19	genotoxic, neurotoxic	Du et al. 2002; Spawn and Aizenman 2012; Tang et al. 2013
Phenol Formaldehyde Resins (9003-35-4)	19	mutagenic, acute toxicity, target organ toxicity, and carcinogen hazards	Lithner et al. 2011; Mato et al. 2001; EC 2013
Boron Compounds (1330-43-4, 10043-35-3, 121-43-7, 1303-86-2)	19	harms development, growth, and reproduction	Bringmann et al. 1980; Black et al. 1993; WHO 1998

Crystalline silica: quartz (X-cide) (14808-60-7)	19	reductions in species richness and biodiversity in benthic communities	Bavestrello et al. 2000
Glyoxal (107-22-2)	19	genotoxic, reproductive toxicity, degenerative effects on pancreas and kidney, low to moderate toxicity to animals	WHO 2004
Methanol (67-56-1)	19	negative effects on swimming behavior of saltwater fish at sublethal concentrations	Baltz et al. 2005
Isotridecanol, ethoxylated (9043-30-5)	12	very toxic to aquatic life, accumulation in organisms possible	Evonik Industries MSDS
Monoethanolamine (141-43-5)	4	moderate ecotoxicity (LC50 >1ppm and <100ppm) to aquatic organisms	USEPA 1996
Alcohols, C12-14, ethoxylated propoxylated (68439-51-0)	2	inherently toxic to aquatic organisms, bioaccumulative; LC50s < 1 mg/L for some algae, invertebrate, and fish species	HERA 2009; EC 2013

Nonylphenol Ethoxylates (CAS# 9016-45-9)

The use of poly (oxyethylene) nonylphenol ether, a nonylphenol ethoxylate, has been reported in 16 out of the 19 chemical disclosures from fracking events in California state waters. The toxicity of nonylphenol ethoxylates (NPEs) increases significantly for nonylphenols with fewer ethoxylate groups attached. Although commercially used NPEs often have 9 or more ethoxylate groups, they readily biodegrade in the natural environment into shorter-chain NP2Es or NP1Es, estimated to be 100 times more toxic, and nonylphenol (NP), estimated to be 200 times more toxic (EC 2002). In a study of algal growth inhibition, NP9E peaked in toxicity after 7 days of biodegradation, while the toxicity of all of the other compounds tested declined immediately (Jurado et al. 2009). Because NPEs biodegrade into the more toxic nonylphenol (NP), NPs resulting from the use of NPEs can pose dangers to the marine environment.

NP is persistent in the aquatic environment, moderately bioaccumulative, and extremely toxic to aquatic organisms (USEPA 2010). In addition to its acute toxicity, NP has well-documented endocrine disrupting effects on fish, including the development of intersex fish and altered sex ratios at the population level (Diehl et al. 2012). NP can also inhibit development, growth, and survival of marine invertebrates (Diehl et al. 2012). Exposure to concentrations as low as 2μg/L significantly altered the swimming behavior of marine copepods (Cailleaud et al. 2011). Biomagnification potential is also a concern for NP. In a study of marine organisms collected from California bays, Diehl et al. (2012) found that NP biomagnified in several trophic relationships: mussel to sea otter, oyster to sea otter, and arrow goby to staghorn sculpin.

Benthic organisms are particularly at risk. NP and NPEs absorb easily to suspended solids and settle to the sediment floor, where concentrations can be several orders of magnitude higher than surface waters (Vazquez-Duhalt et al. 2005). Anaerobic conditions on the sea floor can also facilitate the degradation of NPEs into NP, which can persist for years (Arditsoglu et al. 2012, Ying et al. 2002). Exposure to these heavily polluted sediments can lead to bioaccumulation in benthic organisms. Polychaetes collected from Osaka Bay contained NP concentrations two orders of magnitude higher than the sediment from the study area (Nurulnadia et al. 2014).

In recognition of the hazard NPs and NPEs pose to marine life, EPA has taken several steps to reduce environmental releases of these compounds. In 2006, it set water quality criteria for saltwater of 7μg/L and 1.7μg/L for acute and chronic toxicity, respectively (USEPA 2005). In 2010, it released an action plan to reduce production and use of NPs and NPEs through voluntary phase-outs of some major industrial uses (USEPA 2010). Within the European Union, most uses of NPs and NPEs have been prohibited since 2005.

Methylisothiazolinone (CAS# 26172-55-4, 2682-20-4)

The biocide ingredients 5-Chloro-2-Methyl-4-Isothiazolin-3-One (CMIT) and 2-Methyl-4-Isothiazolin-3-One (MIT) have been used in all 19 fracking events. Kathon, a commercial biocide with a 3:1 CMIT:MIT ratio, is highly genotoxic in vitro (Tang et al. 2013) and MIT is also neurotoxic in vitro (Du et al. 2002). Chronic sub-lethal MIT exposure caused clawed frog tadpoles to exhibit "deficits in visually mediated avoidance behavior and increased susceptibility to seizures, as well as electrophysiological abnormalities in optic tectal function" (Spawn and Aizenman 2012). MIT is also highly toxic to aquatic organisms, with LC50 values of 0.07 to 0.30 ppm for freshwater fish, 0.05 ppm for a marine diatom, and 0.056 ppm for a marine copepod (USEPA 2014b).

Phenol Formaldehyde Resins (CAS# 9003-35-4)

Phenol formaldehyde (p/f) resins were reported in all 19 fracking disclosures. These polymers are persistent and inherently toxic to aquatic organisms (EC 2013). On a hazard scale for polymers, Lithner et al. (2011) ranked p/f resins as a 4 out of 5, citing mutagenic, acute toxicity, specific target organ toxicity, and carcinogen hazards. If released into the marine environment, these micropollutants have the potential to absorb other toxic compounds such as nonylphenol, increasing their toxicity to marine life (Mato et al. 2001). While it may be feasible to filter out these compounds, there is still a dangerous risk of spills, leaks, or accidental discharges.

Boron Compounds (CAS# 1330-43-4, 10043-35-3, 121-43-7, 1303-86-2)

Boron compounds have been used in all 19 fracking events: sodium tetraborate (19 times), boric acid (3 times), methyl borate (3 times), and boric oxide (3 times). While it is a naturally occurring element, boron has been shown to have developmental and reproductive toxic effects on mammals (WHO 1998). Limited studies of boron's acute toxicity to saltwater fish found LC50s (concentrations lethal to 50% of test subjects) ranging from 10.89 to 113 mg boron/L, suggesting low to moderate acute toxicity (Taylor et al. 1985, Thompson et al. 1976). However, research has shown that sodium tetraborate can inhibit green algal growth at concentrations as low as 0.58 mg/L (Bringmann et al. 1980). Rainbow trout embryos have also been shown to be unusually sensitive to boron toxicity, showing mortality and deformity effects at concentrations as low as 0.1 mg/L. (Black et al. 1993).

Trade Secret Compounds

Given the serious concerns regarding phenolic compounds, the use of unidentified oxylated alkylphenols in four fracking events during December 2013 is alarming. In the same disclosures, trade secret protections were also applied to polyoxyalkylene and oxyalkylated amine. In each of the 15 other reported fracking events, an undisclosed mixture of surfactants was used. Trade secret protections have also been used 4 times for petroleum distillate blends, twice for acyclic hydrocarbon blends, and once for resin coated cellulose.

III. The Toxicity of Fracking Chemicals Can Be Increased When They Are Combined with Other Chemicals and Environmental Stressors

The toxic effects of fracking chemicals released into coastal waters may be exacerbated by a number of factors. Toxicity tests generally examine the effects of a single chemical on a single species, often in a laboratory setting with no other environmental stressors. The limitations of these tests can lead to an underestimate of the hazardous potential of a discharge. Chemicals are usually discharged in a mixture, with possible additive or synergistic effects on wildlife. Brian et al. (2007) showed that exposure to a mixture of endocrine disrupting chemicals, all at low-effect concentrations, yielded greater reductions in fish reproductive performance than were attributable to a single contaminant. Similarly, a toxic effect on one species can produce indirect effects throughout the community through changes in predation, competition, and other interspecific interactions (Geiszinger et al. 2009). A database comparison of single-species and multiple-species toxicity tests found two-fold differences in some threshold concentrations for the same species depending on the type of test used (De Laender et al. 2009). A 1999 EPA review of 77 single-species aquatic toxicity tests found that although they were qualitatively reliable, 21% underestimated ecosystem impacts or overestimated no-effect concentrations (USEPA 1999). Certain marine species may also be at greater risk for exposure because of their attraction to offshore oil platforms. Studies have shown that the submerged structures of oil platforms act as artificial reefs for marine life. A study of two economically important but overfished rockfish species found significantly greater numbers at California oil platforms than nearby natural reef sites (Love et al. 2005).

Chemical stressors can also combine with other environmental stressors to cause greater impacts at the individual, population, and community level. In a laboratory setting, Gergs et al. (2013) found that combined stress from predation and nonylphenol exposure caused extinction in a test population, while populations exposed to only one stressor remained viable. Anthropogenic climate change, in particular, introduces a set of environmental stressors that can greatly affect the tolerance of marine life to chemical exposure. For example, changes to UV intensity, temperature, and salinity can affect the toxicity of PAHs, PCBs, and pesticides by increasing uptake (Hooper et al. 2013). Life cycle disruption due to altered temperatures or habitat loss may increase toxicant sensitivity or exposure for some organisms (Moe et al. 2013). Increasing disruption from climate change further complicates the task of extrapolating adequate, ecosystem-protecting limits for chemicals from single-species toxicity tests.

IV. Recent Scientific Studies Indicate that Produced Water May Be More Harmful to Marine Life than Previously Assessed

Produced water -- the fluid that comes to the surface once the production of oil and gas has begun -- contains toxins gathered from the subsurface rock formation, as well as any chemicals injected during fracking or acidizing. Harmful substances from the rock formation include heavy metals such as lead, organic contaminants such as benzene and toluene, and naturally occurring radioactive materials from deep in the formation (USGAO 212). By extending the lifespan of wells, fracking can increase the total volume of produced water discharged to marine waters over the well lifetime, in addition to adding harmful fracking chemicals to produced water.

The Coastal Commission evaluates the harms to marine life from produced water when making its consistency determination for NPDES permits for discharges from offshore oil and gas platforms located in federal waters. Apart from the added dangers from fracking chemicals, recent studies indicate that produced water can be more harmful to marine life than previously assessed. We recommend that the Coastal Commission update its analysis of produced water to take into account these new studies.

The Coastal Commission's 2013 most recent consistency determination (CD-001-13) for the issuance of a general NPDES permit for discharges from offshore oil and gas platforms located in federal waters off the coast of Southern California includes a section on potential impacts of produced water discharges to marine resources and water quality. This section cites entirely from studies summarized in the produced water discharge section of a 2010 Bureau of Ocean Energy Management (BOEM) report, entitled *Updated Summary of Knowledge: Selected Areas of the Pacific Coast*. The majority of the studies cited in the relevant section, *Effects of Produced Water Discharges,* were published before 2000 and a 2005 study was the only cited reference from after 2002.

Since 2005, researchers have developed new evidence for potential harmful effects of produced water discharges on marine life. Muller et al. (2010) used a Dynamic Energy Budget (DEB)-based model to re-examine data from a previously cited study by Osenberg et al. (1992) of mussels exposed to produced water discharges in California waters. This new approach allowed them to evaluate long-term effects not accounted for in the initial analysis, and subsequently conclude that "the potential environmental impacts of produced water are even stronger than commonly believed" (Muller et al. 2010).

Much of the recent work on produced water impacts has been focused on oil platforms in the North Sea. By utilizing longer exposure periods, different life stages, and more sensitive effect indicators, researchers have demonstrated more sublethal impacts to marine life than had been previously considered. Atlantic cod exposed for 44 weeks to environmentally realistic concentrations of polycyclic aromatic hydrocarbons (PAHs) and alkylphenols (APs), the most concerning toxicant classes in produced water, developed significant DNA adducts between 16 and 44 weeks (Holth et al. 2009). In contrast, many older studies of produced water toxicity exposed organisms for periods shorter than 16 weeks. Bohne-Kjersem et al. (2010) exposed Atlantic cod from the egg to the fry stage to produced water concentrations of 0.1% and 0.01%, the estimated distance-equivalent of 100m and 1000m from the platform. After 90 days, fry showed altered DNA protein expressions related to muscle development, rod/retina function, cellular signaling and tissue morphology. The aqueous fraction of produced water from a

Canadian offshore platform was also shown to effect the expression of immune related genes in Atlantic cod (Pérez-Casanova et al. 2012).

These studies, along with other evidence regarding the impacts of produced water discharges, are reviewed extensively by Bakke et al. (2013). Impacts include endocrine disruption, loss of membrane integrity, cytotoxicity, gene expression changes, DNA adducts, hepatic lipid composition, and reproductive disorders. The authors discuss the difficulty of linking the individual effects from produced water discharges to population-level effects, given the inherent difficulty of documenting population-scale impacts in the field and establishing causality for a single factor. They note that sub-lethal effects have only been demonstrated at concentrations equivalent in distance to 1-2 kilometers, but acknowledge the possibility of subtle, cumulative effects from operational discharges that are not measurable at present (Bakke et al. 2013). For example, haddock and Atlantic cod collected from the North Sea showed a greater biological response in areas of higher intensity oil production, but even fish collected away from the platforms showed increased DNA adducts and evidence of PAH exposure (Balk et al. 2011). This study suggests the potential for point-source pollution, such as produced water, to affect a population beyond the dilution radius.

V. Conclusion

The Center appreciates the Coastal Commission's investigation and staff recommendations concerning offshore fracking. Given the serious harms posed to marine life from fracking, we urge the Coastal Commission to assert its authority to regulate oil and gas activities in the coastal zone, and to deny coastal development permits and object to consistency determinations that do not protect wildlife, marine fisheries, and the ecological balance of the coastal zone. Cal. Pub. Res. Code, § 30001.

We are submitting copies of the cited studies on a compact disk to the Coastal Commission. Please contact Shaye Wolf at (415) 632-5301 if you have any questions about these comments.

Sincerely,

Shaye Wolf

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